PATENT SPECIFICATION (11) 1 455 572

1 455 572

(21) Application No. 8350/73 (22) Filed 20 Feb. 1973
(23) Complete Specification filed 13 Feb. 1974
(44) Complete Specification published 17 Nov. 1976
(51) INT. CL.[2] E04C 3/28
(52) Index at acceptance
E1W 2B13 2B15 2B16 2B18 2B1 2B2
(72) Inventors MICHAEL DOOTSON
JEREMY MICHAEL WOODING

(19)

(54) IMPROVEMENTS RELATING TO BEAMS OF FIBRE REINFORCED PLASTICS

(71) We, BRITISH AIRCRAFT CORPORATION LIMITED, a British Company, of 100 Pall Mall, London, S.W.1., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to beams formed of fibre reinforced plastics material.

According to the present invention, a fibre reinforced plastics beam having a web region and a flange region extending generally normally with respect to one another, includes a plurality of fibre reinforced plastics structural elements and a fibre reinforced continuous capping layer, the structural elements each having a base region and a wall region at the edge of the base region, the wall region including opposed end portions which are formed for bonding to similar portions on successive structural elements, and at least one side portion lying between the opposed end portions, the structural elements being so formed that when the said end portions of successive structural elements are bonded to one another, the base regions lie in substantial alignment and the side portions lie in such alignment that the capping layer can be continuously bonded thereto, the said side portions and the capping layer jointly forming the beam flange region and the base regions forming at least part of the beam web region.

Preferably the beam is of 'I'-shape in cross-section and the structural elements are bonded directly or indirectly to one another in back-to-back relationship.

It is also preferable that the structural elements are each formed of a plastics material including two or more layers of mainly uni-directional fibres, alternate fibre layers being placed in alternate angular orientations at a predetermined angle to a lengthwise axis of the beam.

Similarly, it is preferable that the capping layer is formed of uni-directional fibred material, the fibres extending lengthwise of the beam.

Some preferred embodiments of beams according to the present invention are now described with reference to the accompanyings drawings.

In these drawings:—

Figure 1 is a side view of a beam which is I-shaped in cross-section.

Figure 2 is a cross-sectional view of the beam in which the section is taken on like II-II of Figure 1.

Figure 2A is a view similar to that of Figure 2 but illustrating an alternative embodiment,

Figures 3 and 4 are side views of further alternative embodiments,

Figure 5 is a side view of an embodiment incorporating intersecting beams, and,

Figure 6 is a plan view of the embodiments of Figure 5.

Referring initially to Figures 1, 2, and 2A, a beam of I-shaped cross section is formed of a series of rectangular structural elements 1. Each of these elements 1 has a flat base 2 with a side wall 3 extending around its periphery from one side thereof. The base 2 and the wall 3 are formed in one piece by laminations of uni-directional fibred material, the fibres of those alternate laminations forming the base 2 extending at angles of $+\theta°$ and $-\theta°$ to an axis 4 extending lengthwise of the beams, as shown in Figure 1.

The outer surface of the walls 3 are formed flat and normal to the base 2. The surface of the base 2 remote from the walls is also formed flat. Thus the elements 1 can be placed end-to-end with their opposite end walls 5 adjacent and bonded together with a layer of adhesive, and also can be placed back-to-back and similarly bonded.

The outer faces of those portions of the

walls 2 of each element 1 not bonded together, that is the outer faces of the top and bottom walls 6 as illustrated, are arranged to lie smoothly continuously with one another. To cap each of the continuous top and bottom surfaces thus provided is bonded a capping member 7 formed of uni-directional fibred material, the fibres extending lengthwise of the beam. The adhesive layer, where bonding is required, is referenced 8.

In Figure 2A, there is illustrated an embodiment in which a low density core material 9, for example a honeycomb) of plastics or lightweight metallic material) or a foamed plastics material is bonded between those structural elements 1 lying back-to-back. This is to stabilise the web to prevent shear buckling and/or to provide additional torsional rigidity.

The flange members 7 may be of a constant or of varying cross-section along their length.

In Figure 3, structural elements 1*a* are illustrated incorporated in a curved beam. In such an embodiment the elements 1*a* have their end walls 5*a* formed to converge at the centre of curvature of the beam. Furthermore, the elements have their walls 6*a* curved at suitable curvature.

In Figure 4, the structural elements 1*b* are illustrated incorporated in a cranked beam. In such an embodiment the end walls 5*b* are formed to converge with one another. The walls 6*b* in each element are straight but are of different lengths.

A beam according to the invention is of particular use where one beam intersects another and one web is accordingly interrupted. In the embodiment illustrated in Figures 5 and 6, a transversely extending beam 10 interrupts the web of a beam formed from structural elements 1*c*. The elements 1*c* as illustrated have upper and lower walls 6*c* and spaced end walls 5*c*. The beam 10 is of I-shape in cross-section; it may be of a construction according to the present invention as illustrated or it may be of some other construction. It has, at least in the locality of the intersection, an overall depth between its upper and lower faces equal to the depth between the upper and lower walls 6*c* of the elements 1*c*. Accordingly the elements 1*c* are formed with their walls 6*c* locally stepped at 11 to clear the flanges of the beam 10 so that the walls 5*c* can protrude in between the flanges thereof to contact and be bonded to the web. The capping members 7*c* are continuous and extend above and below the beam 10 as drawn.

In order that a beam according to the invention can be readily fabricated, the structural elements require to be accurately formed. One moulding technique which has been found to be suitable involves the use of a rigid former having a central opening machined to provide the required external dimensions of the structural elements. This is designed to lie between two platens of a press. A flexible former, e.g. of a rubber or a rubber-like material, is shaped to enter easily into the rigid former with the material to be moulded laid upon it, but to be of a thickness greater than that of the rigid former so that when compressed by the platens, the flexible former deforms under pressure to force the material to be moulded against the sides of the rigid former. Heat is applied to allow the material to be moulded to deform easily and to subsequently set rigidly.

The material to be moulded conveniently comprises sheets of fibres pre-impregnated with a thermo-setting resin. These sheets are laid-up upon the flexible former and, where necessary, release agents and excess resin absorbing layers are placed adjacent the forming surfaces.

At the corners of the structural elements, the individual pre-impregnated sheets are locally trimmed so that excess wall thickness is not built up where the sheets would otherwise overlap. This ensures uniformity of shear force transmission at the corners and at least minimises any warping with change in temperature.

The invention has application to beams of the type having a web which transmits the majority of any shear loads and at least one flange at an edge of the web which transmits the majority of any tensile or compressive loads due to bending and which stabilises the web, the beams being thus of generally I-shape, T-shape or channel-shape in cross section or variations thereof. Where the beam is T-shape in cross-section, the wall 3 of each structural element may extend only along those edges at which bonding is effected. As can be seen from the drawings, those portions of the walls referenced 6, 6*a*, 6*b*, and 6*c*, together with the capping member 7, form the flange or flanges of the beam whilst the bases 2, together with the core material 9 when utilized, form the web of the beam.

WHAT WE CLAIM IS:—

1. A fibre reinforced plastics beam having a web region and a flange region extending generally normally with respect to one another, including a plurality of fibre reinforced plastics structural elements and a fibre reinforced continuous capping layer, the structural elements each having a base region and a wall region at the edge of the base region, the wall region including opposed end portions which are formed for bonding to similar portions on successive structural elements, and at least one side portion lying between the opposed end portions, the structural elements being so

formed that when the said end portions of successive structural elements are bonded to one another, the base regions lie in substantial alignment and the side portions lie in such alignment that the capping layer can be continuously bonded thereto, the said side portions and the capping layer jointly forming the beam flange region and the base regions forming at least part of the beam web region.

2. A beam according to claim 1 of generally I-shape in cross section in which the structural elements are bonded directly or indirectly to one another in back-to-back relationship.

3. A beam according to claim 1 or claim 2 wherein the structural elements are each formed of a plastics material including two or more layers of mainly uni-directional fibres, alternate fibre layers being placed in alternate angular orientations at a predetermined angle to a lengthwise axis of the beam.

4. A beam according to any one of the previous claims wherein the capping layer is formed of a uni-directional fibred plastics material, the fibres extending lengthwise of the beam.

5. A beam according to claim 2 in which the structural elements are bonded indirectly to one another and are spaced by and bonded to a honeycomb or foamed plastics layer.

6. A beam substantially as described with reference to the accompanying drawings.

D. J. SAUL,
Chartered Patent Agent.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1976.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 455 572 COMPLETE SPECIFICATION
3 SHEETS

Fig. 1.

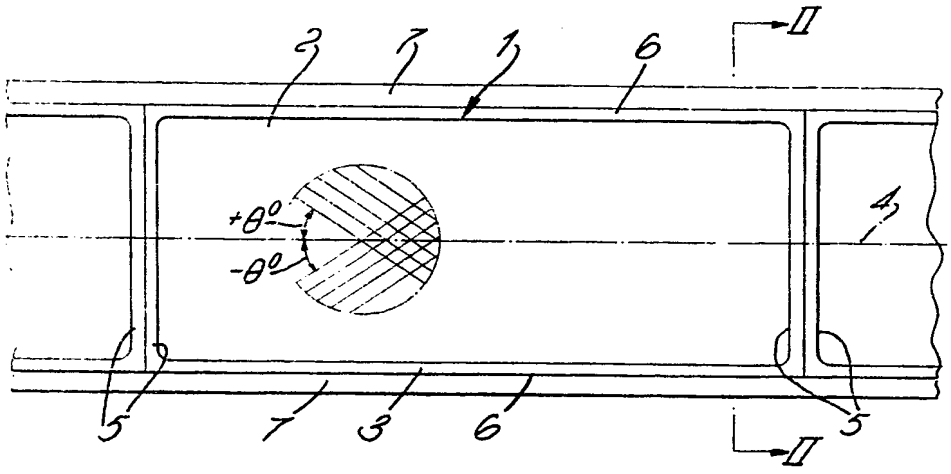

Fig. 2.

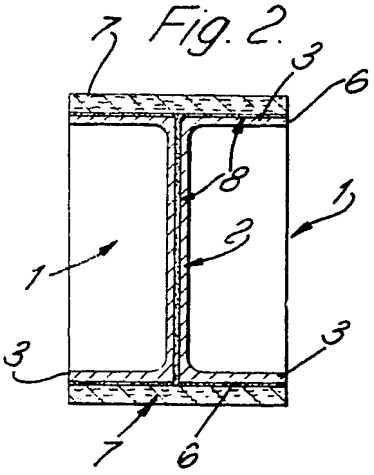

Fig. 2A.

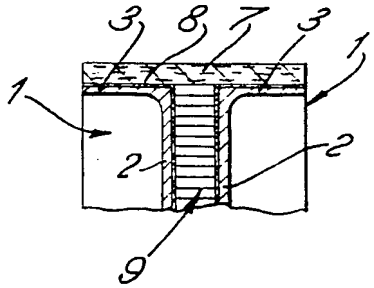

Fig. 3.

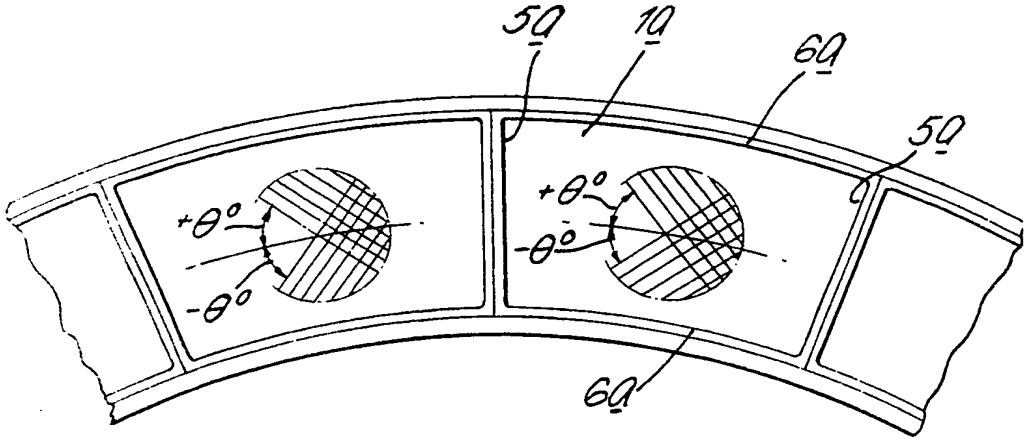

Fig. 4.

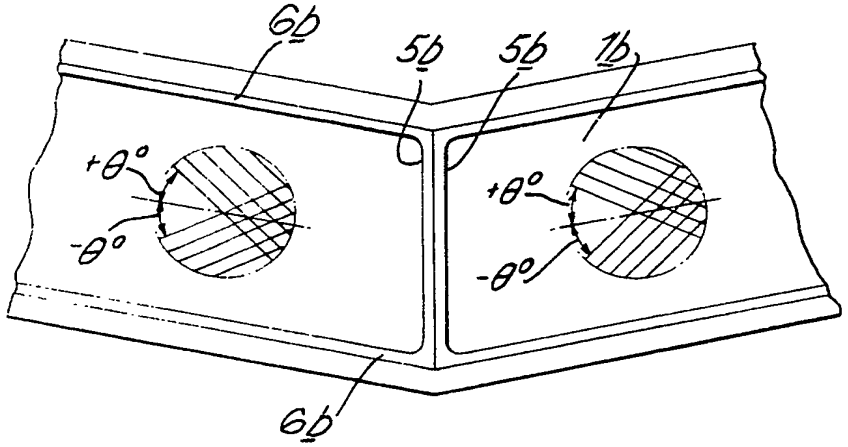

Fig. 5.

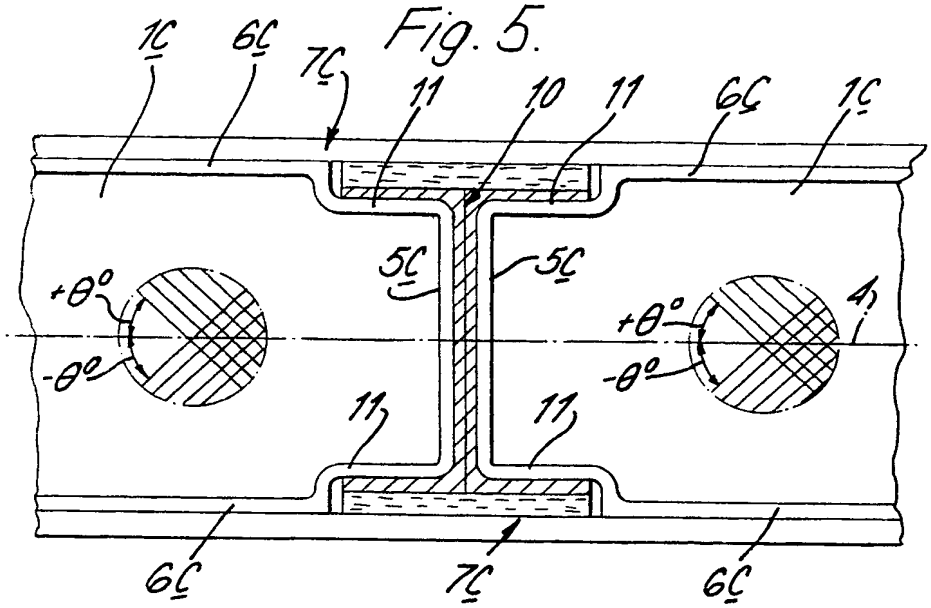

Fig. 6.